A NEW DETAILED STRUCTURAL HISTORY OF THE THARSIS REGION OF MARS, R. C. Anderson[1], M. P. Golombek[1], Franklin, B. J.[1], K. L. Tanaka[2], J. M. Dohm[2], J. Lias[2], and J. Higdon[3], [1]Jet Propulsion Laboratory, Pasadena, CA 91011 , [2]U.S. Geological Survey, Flagstaff AZ 86001, [3]Dept. of Earth & Planetary Sciences, Washington University, 63130, randerson@jpl.nasa.gov

Introduction

Tharsis dominates the western hemisphere volcano-tectonic activity on Mars. Activity associated with it produced large and small extensional and compressional structures within the surrounding volcano-tectonic provinces largely during the Noachian and Hesperian [1]. These structures include grabens, normal faults, and wrinkle ridges. The Tharsis-related radial pattern of faults and grabens show a direct relation between the center of Tharsis and the surrounding provinces [1]. Previous studies have established a preliminary chronological history of each volcano-tectonic province based on detailed stratigraphic and cross-cutting relationships and crater stastitics [2, 3, 4]. However, unlike other studies which concentrated on specific provinces [1] or were highly generalized [2], this intensive study of faults and grabens within and surrounding Tharsis region (encompasing the entire western hemisphere of Mars) was undertaken to determine the regional, spatial, and temporal relations of features with the surrounding geology. We mapped, characterized, and dated twenty-four thousand structures within most of the western hemisphere of Mars.

Methodology

Structures were mapped [5,6] and digitized using thirty Viking 1:2,000,000 scale subquadrangle photomosaic base maps for the region bounded by 65° N to 65° S latitude and 45°W to 160° W longitude. In this study, structures have been classified as faults, grabens, and ridges. Each digitized structure consists of an x-y reference for its beginning and ending points. The x-y points were then converted into latitude/longitude measurements for correlation with the 1:2,000,000 base maps. Structures were then characterized with respect to structural type and stratigraphic age. Structural classification was divided into two major categories based on positive and negative relief. Each of these major categories where further subdivided into structural subcatergories according to the type of structure, its subsequent modification and its relation to certain surrounding geologic features (Table 1).

For regional age correlation, each structure was assigned an age based on previous work [1,2,3,4]. Due to the large number classification schemes, all stratigraphic ages were compared to the age classification of Dohm et al., (1997)[7]. In their study, features were delineated into five stratigraphic stages based on detailed cross-cutting relationships and crater counts. A sixth stage was included in this study to further subdivide the Amazonian activity as at Alba Patera [3]. The six stratigraphic stages were then correlated to the other volcano-tectonic provinces within Tharsis region (Table 2).

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Preliminary Results and Conclusions

Structural Classification

From the 24,000 structures, 99% of them have been assigned a structural type, Of those identified, 54% were classified as simple grabens, 8% as wide tension cracks, 7% altered simple grabens, 7% wrinkle ridges, 5 % structurally controlled troughs, and 19% other types.

Stratigraphic Age

For the stratigraphic age data, about half (12, 409 or 52%) of the structures have been assigned an age at this time, mainly for the major volcanic provinces identified in Table 2. The majority of the structures that have not been assign an age include wrinkle-ridges and grabens of Valles Marineris, Tharsis Montes, and the region centered around Memnonia Fossae. For the structures with ages assigned: 45% of the grabens are classified as Stage 1; 24% Stage 2; 7% Stage 3; 8% Stage 4; 13% Stage 5; and 3% Stage 6.

From the preliminary data, more than half of structures mapped within the Tharsis region are Noachian. These grabens are dominant in the Syria Planum/Thaumasia and the Tempe provinces. This indicates that activity was concentrated in these regions during the Noachian, and that faulting continued into the Early Hesperian (Stage 2).

During the Early to Middle Hesperian there was a sharp decrease in the amount of faulting with the Syria Planum/Thaumasia and Tempe Terra remaining active. This decrease in activity was concomintant with a peak in wrinkle-ridge formation [4]. At the beginning of the Late Hesperian, grabens faulting increased (Stages 4 and 5) with a majority of these structures resulting from the formation of Alba Patera. It is interesting to note, that although the formation of Alba was dominant during the Late Hesperian to Early Amazonian, the region around Claritas Fossae was still very active. The last of the Tharsis pulse resulted in the formation of Stage 6 grabens which appeared around Alba Patera and in the grabens around the large volcanoes of Tharsis. This decrease activity of this stage may indicate a final pulse of Tharsis formation. This history will be updated once all the structures have been classified and dated.

Reference

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TABLE 1 Categories of structural features identified in the Tharsis region.
Negative Topographic Features

grabens
Simple Grabens (flat, visible floor and clean, smooth walls)
1. Narrow simple grabens (0-5 km wide)
2. Wide simple grabens (>5 km wide)

Modified Simple Grabens.
3. Altered simple grabens (appear to be partly eroded or filled in)
4. Pit chain grabens

Complex Grabens/Rifts
5. Complex grabens (10-50 km wide, stepped sides)
6. Altered complex grabens (appear to be partly eroded or filled in)

Tension Cracks
7. Narrow tension cracks (0-500 m wide)
8. Wide (modified) tension cracks (> 500 m wide)
9. Tension cracks with pit chain
10. Tension cracks associated with volcanoes

Other
11. Structurally-controlled fluvial channels
12. Structurally-controlled sapping valleys
13. Structurally-controlled troughs
14. Polygonal troughs

Positive Topographic Features
Ridges
15. wrinkle ridges (linear hill with crenulation, may branch, curve or imbricate)
16. wide linear hills (> 5 km wide)
17. narrow linear hills (0-5 km wide)

Scarps
18. single scarps

TABLE 2 Correlation of regional and provincial fault sets and stages in the Tharsis region.

Tharsis/Thaumasia [7]	Tempe [2]	Alba [3]	Ulysses [1]	Syria [1]
(1) Noachian	Noachian Stages 1-5	Stage I	none	Stage IA & IB
(2) Late Noachian-Early Hesperian	none	Stage II	Fault Set 1	Stage IIA
(3) Early - Middle Hesperian	Hesperian Fault Set 1 + ridges	none	Fault Set 2 &3	Stage IIB
(4) Late Hesperian	Hesperian Fault Sets 2 & 3	none	Fault Set 4	Stages III1, III2, III3, IVA, IVB1, IVB2
(5) Late Hesperian - Early Amazonian	Amazonian Fault System	Stage III	Amazonian Fault Set 1	Stages V, VI1, VI2
(6) Middle - Late Amazonian	none	Stage IV	Amazonian Fault Set 2	none